EGU24-3947, updated on 02 Nov 2024
https://doi.org/10.5194/egusphere-egu24-3947
EGU General Assembly 2024

Pumped hydropower storage operation in open-pit lignite mines does not compromise the pit lake and groundwater chemistry

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Experiences with open-pit mine flooding in German lignite mining regions show that hydrogeochemical processes can become critical ecological and economic factors for the realisation of Pumped Hydropower Storage (PHS) projects. Depending on sulphide and oxygen availability as well as buffering and dilution processes, acid mine drainage and increased sulphate and metal concentrations can have negative impacts on ecosystems and groundwater resources as well as the installed PHS infrastructure. As part of the ATLANTIS project, this study aimed to quantify changes in water composition in the lower storage reservoir resulting from PHS operation under different hydrogeochemical boundary conditions.

For the present parameter study, data sets on hydrochemistry, hydrogeology and morphology of flooded German lignite mines were used to develop a numerical hydrochemical reaction path modelling framework. The chemical calculations were realised with PHREEQC (Parkhurst and Appelo, 2013), while the input and output data were managed via the Python-based simulation framework and PHREEQPY (Müller, 2022). The implemented parallelised workflow made it possible to analyse and evaluate more than 12,000 parameter combinations for various hydrogeological baseline scenarios. The influencing factors considered in these scenarios include the initial flooding of the open-pit mines, source terms due to precipitation, groundwater inflow and surface run-off, mineral availability in the sediments and the pumping cycles between the lower and upper storage reservoirs of the PHS installation.

The simulation results show that the volume of water migrating between the lower reservoir and its adjacent aquifers during the pumping cycles is too small to influence the water quality of the reservoir on the short term. The long-term availability of buffer capacities in the reservoir and the present mine waste dumps determine the eventual development of acidic or pH-neutral mine water. Sulphate concentrations are mainly influenced by dilution processes, what underlines the relevance of considering additional source and sink terms. Depending on these as well as the availability of oxygen and quantities of sulphide present in the adjacent sediments, the time required to achieve a chemical equilibrium in the lower storage reservoir varies from a few weeks to several years.

In summary, the operation of pumped storage power installations in former open-pit lignite mines can be safely realised if sufficient acid buffer capacities are available and dilution through

additional water in- and outflows is sufficiently high.

The present study has received funding from the Research Fund for Coal and Steel—2020, under grant agreement No. 101034022 (ATLANTIS).

Literature

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